LINEAR TECHNOLOGY

DESIGN NOTES

LTC1451/52/53: 12-Bit Rail-to-Rail Micropower DACs in an SO-8

Design Note 96

Hassan Malik and Jim Brubaker

The LTC®1451, LTC1452 and LTC1453 are complete, single supply, rail-to-rail voltage output 12-bit digital-to-analog (DAC) converters. They include an output buffer amplifier and a space saving SPI compatible three-wire serial interface. There is also a data output pin that allows daisy-chaining multiple DACs. These DACs use a proprietary architecture which guarantees a DNL (Differential Nonlinearity) error of less than 0.5LSB. The typical DNL error is about 0.2LSB as shown in Figure 1. There is a built-in power-on reset that resets the output to zero scale. The output amplifier can swing to within 5mV of V_{CC} when unloaded and can source or sink 5mA even at a 4.5V supply. These DACs come in an 8-pin PDIP and SO-8 package.

5V and 3V Operation

The LTC1451 has an on-board reference of 2.048V and a nominal output swing of 4.095V. It operates from a single 4.5V to 5.5V supply dissipating 2mW ($I_{CC(TYP)}$ = 400µA).

The LTC1452 is a multiplying DAC with no on-board reference and a full-scale output of twice the reference input. It operates from a single supply that can range from 2.7V to 5.5V. It dissipates 1.125mW ($I_{CC(TYP)}$ = 225µA) at a 5V supply and a mere 0.5mW ($I_{CC(TYP)}$ = 160µA) at a 3V supply.

The LTC1453 has a 1.22V on-board reference and a convenient full scale of 2.5V. It can operate on a single supply with a wide range of 2.7V to 5.5V as shown in Figure 2. It dissipates 0.75mW ($I_{CC(TYP)}$ = 220µA) at a 3V supply. The digital inputs can swing above V_{CC} for easy interfacing with 5V logic.

True Rail-to-Rail Output

The output rail-to-rail amplifier can source or sink 5mA over the entire operating temperature range while pulling to within 300mV of the positive supply voltage or ground. The output swings to within a few millivolts of either

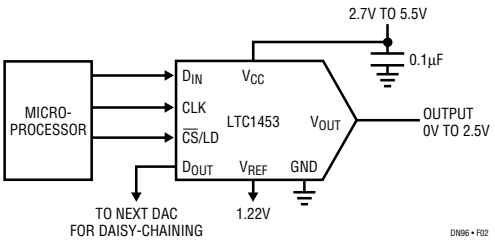

Figure 2. The 3V LTC1453 is SPI Compatible and Talks to Both 5V and 3V Processors

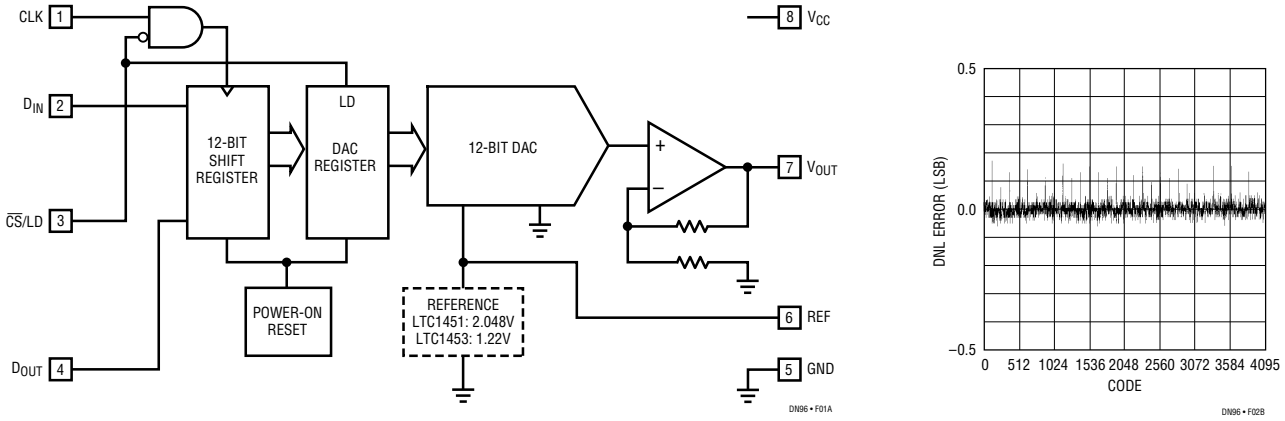

Figure 1. Proprietary Architecture Guarantees Excellent DNL

supply rail when unloaded and has an equivalent output resistance of 50Ω when driving to either rail. The output can drive a capacitive load of up to 1000pF without oscillating.

Wide Range of Applications

Some of the applications for this family include digital calibration, industrial process control, automatic test equipment, cellular telephones and portable battery-powered applications where low supply current is essential. Figure 3 shows how to use an LTC1453 to make an opto-isolated digitally controlled 4mA to 20mA process controller. The controller circuitry, including the opto-isolator, is powered by the loop voltage that can have a wide range of 3.3V to 30V. The 1.22V reference output of the LTC1453 is used for the 4mA offset current and V_{OUT} is used for the digitally controlled 0mA to 16mA current. R_S is a sense resistor and the LT®1077 op amp modulates the transistor Q1 to provide the 4mA to 20mA current through this resistor. The potentiometers allow for offset and full-scale adjustment. The control circuitry consumes well under the 4mA budget at zero scale.

Flexibility, True Rail-to-Rail Performance and Micropower; All In a Tiny SO-8

The LTC1451, LTC1452 and LTC1453 are the most flexible micropower, stand alone DACs that offer true rail-to-rail performance. This flexibility along with the tiny SO-8 package allows these parts to be used in a wide range of applications where size, power, DNL and single supply operation are important.

Table 1. LTC Serial Voltage Output DACs

Part	V_{CC} Range	Reference	Full Scale	I_{CC}
LTC1451	4.5V to 5.5V	2.048V-Internal	4.095V	400µA at 5V
LTC1452	2.7V to 5.5V	External	2 × REF	225µA at 5V
LTC1453	2.7V to 5.5V	1.22V-Internal	2.5V	250µA at 3V
LTC1257	4.75V to 15.75V	2.048V-Internal (2.5V to 12V-External)	2.048V (2.5V to 12V)	350µA at 5V

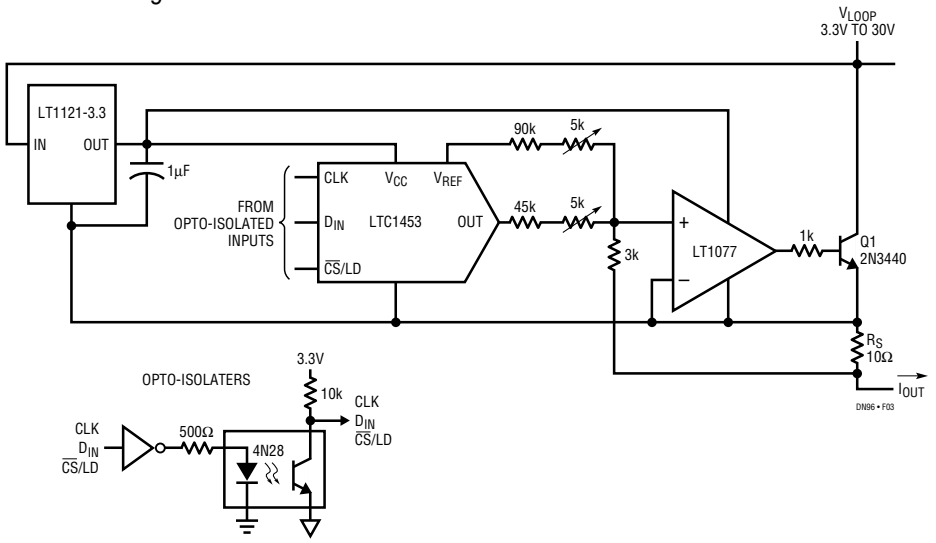

Figure 3. 4mA to 20mA Process Controller Has 3.3V Minimum Loop Voltage

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Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7487
(408) 432-1900 • FAX: (408) 434-0507 • TELEX: 499-3977

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